LAUNCHER HOLD AND RELEASE MECHANISM FOR LAUNCH VEHICLE

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Abstract

The ISRO Satellite Launch Vehicle now under development is proposed to be launched from Sriharikota range using the existing launch pedastal. Prior to vehicle lift-off, the strapon motors are ignited by a single command. A hold down and release system is being developed for holding the vehicle during the strapon engine start up and to release the vehicle on command. The constraints on interface and space available combined with the specific functional requirement demanded to go for a compact release system. Four release mechanisms employing the collet grip principle are used to hold the vehicle. A multiple redundant hydraulic system is used for actuating the mechanisms. This paper describes the efforts made towards realising the release mechanisms. A brief description of the hydraulic system also is presented.

1.Introduction

The launch vehicle currently under development is designed to place 2500 kg class satellites into geosynchronous orbit. The booster stage of the vehicle is made up of a solid propellant core motor strapped with four liquid propellant motors. First, the strapon motors are ignited by a single command. The launcher hold and release system is used to hold the vehicle to the launch pedastal against disturbing forces during the strapon engine start-up and thrust build up. Disturbing forces include induced moment load due to wind and non ignition of one or more strapon motors. Launcher hold and release system releases the hold on vehicle upon remote command after verifying the performance of strapon motors. The core motor is ignited after confirming the release of hold on vehicle. The vehicle lifts-off only after the core motor is ignited.

2. System requirements

The launcher hold and release system requirements are as follows.

- It shall keep the vehicle kinematically stable against worst combination of disturbances while on launch pad.
- It shall release the hold on vehicle upon remote command.
- The mechanism shall have interface with the core base shroud of vehicle. Mechanisms shall be symmetrically oriented.
- It shall have defined interface with the launch pedastal.
- Mechanism shall provide its functional status after release of hold on vehicle
- The release function shall be completed within 0.25 seconds.
- Single point failure chances must be eliminated.
- Debris fly-off and shock loading on vehicle shall be avoided.
- There shall not be any pull out requirement for the vehicle

3. System description

The launcher hold and release system consists of four mechanisms holding the vehicle which are released by a hydraulic system on command. These four mechanisms are located in the plane of strapon motors. They are interfaced with the vehicle core base shroud and the vehicle support block. Mechanisms are instrumented to provide the functional status after completion of release function.

3.1.The mechanism

The mechanism works on collet grip principle. It employs a special collet designed to grip a shaft with tapered interface (Fig.1). The shaft is mounted on the vehicle core base shroud. The collet petals are initially made in a conical shape. They are deformed to grip the shaft by a sleeve. The sleeve is also designed to

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work as a piston inside a cylindrical body. A helical compression spring keeps the sleeve in position so that

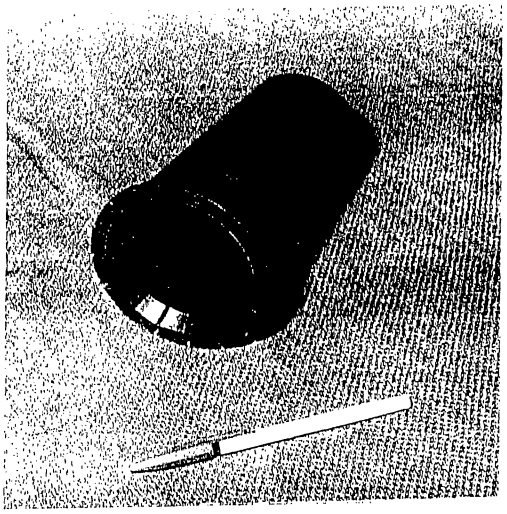

Fig.1 : Collet

the collet petals are held in the deformed state. The collet and body are connected through a base plate. Body of mechanism has two inlet ports for the hydraulic power input. Mechanism assembly is mounted on to the vehicle support block.

The mechanism is compact in design. The ground part with collet has an overall dimension of 194mm dia x 250mm. The vehicle part is the tapered shaft of 30 mm dia x 270mm. Mechanical interfaces for 3 different type of sensors are incorporated in the design. Sensors are provided with redundancy.

3.2.Working principle

Fig.2 shows the cross sectional view of mechanism in assembled condition. A pull on shaft causes the collet petals to move radially outward. However, the sleeve surrounding the collet petals keep it in position and the pull load is transmitted to the body through base plate. Tightening of the hexagonal nut on the shaft applies clamp load between vehicle core base shroud and support block. Clamp load on vehicle is released by forcibly moving the sleeve downwards. Present design needs only 10mm movement of sleeve to release the grip of collet on shaft. The sleeve is moved by hydraulic power. The mechanism in released condition is shown in Fig. 3.

3.3.Hydraulic system in brief

All four mechanisms are released simultaneously using a common hydraulic system. The hydraulic system is based on accumulator circuit. The lines to mechanisms are drawn from separate manifold blocks having redundant control valves.

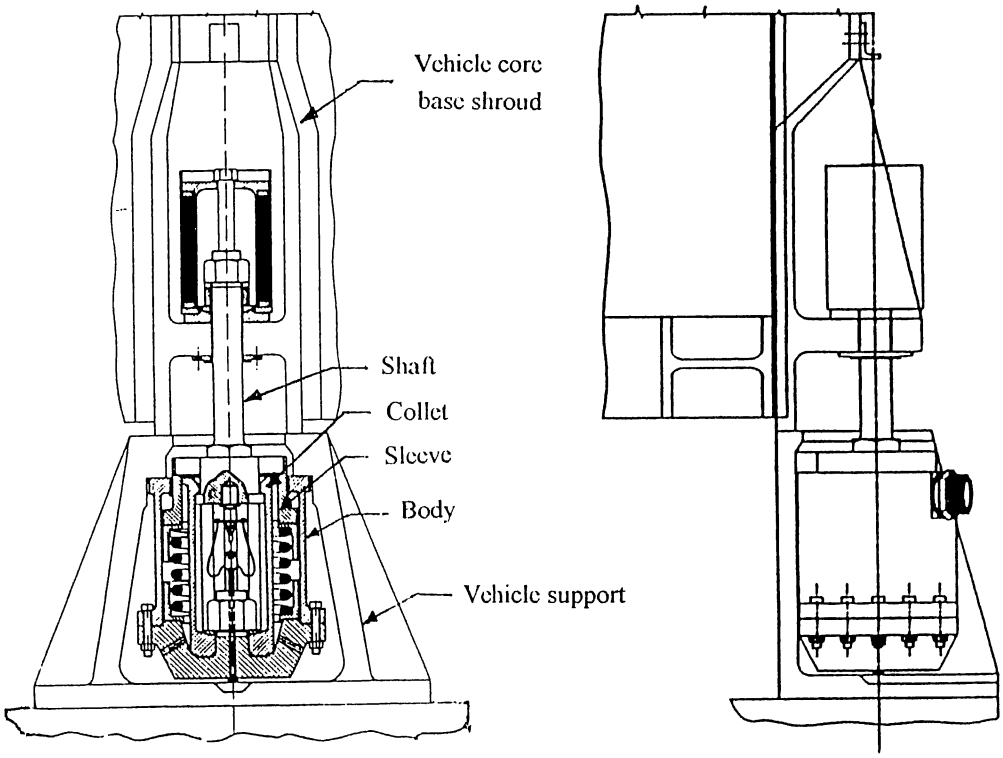

Fig.2 : Sectional view of mechanism assembly

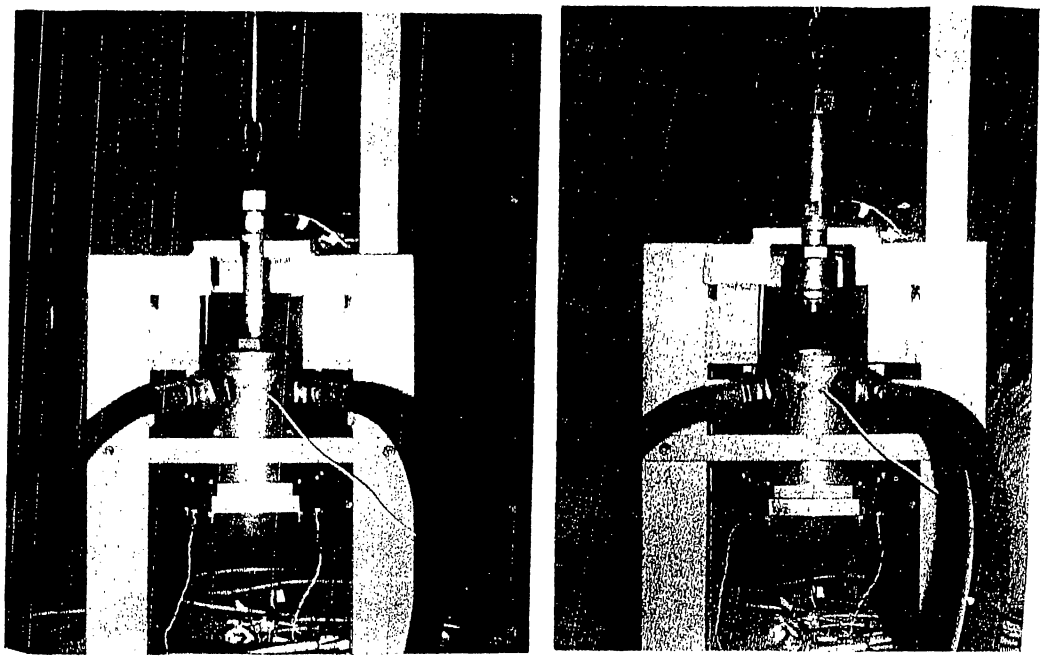

Fig.3 : Mechanism assembly before and after release

Special high response solenoid valves are selected for the system. Length of hydraulic lines from manifold block to mechanisms are kept equal. This ensures synchronisation of mechanism release. Prefilling the lines and close location of accumulator and control valves ensures fast response towards release. Care has been taken to protect the lines and control valves from the severe environment due to the exhaust of strapon motors.
Hydraulic system works on blow-down mode. It operates at a pressure of 18 MPa.

4. Design specifications for mechanism

- The mechanism is to be designed for an axial tension of 370 KN and shall apply clamp load at the vehicle ground structure interface to keep them in contact even under the worst disturbances.

- It shall have interface for vehicle core base shroud and support block.
- It shall have interface for redundant hydraulic inlets.
- It shall have interface for sensors to provide functional status.
- It shall operate under the environment created by the thrusting strapons.

5. Design of mechanism

The structural components of mechanism are analysed using NISA software package. The special collet is analysed by 3D finite element modelling. A typical stress contour of one petal of collet is presented in Fig.4.
The time required for sleeve movement to release the shaft from collet grip is 0.01 seconds.

6. Specific design features

The collet employed in the mechanism has a cylindrical hub at bottom and concentric petals of length 150mm. Petals are initially in conical shape and is deformed by 5.1mm during assembly. Tip of the petals are so configured to have minimum unbalanced moment at its elastic hinge. It is made of high strength steel with special fabrication process. The number of collet petals are fixed so as to have minimum interface due to its curvature during the release.

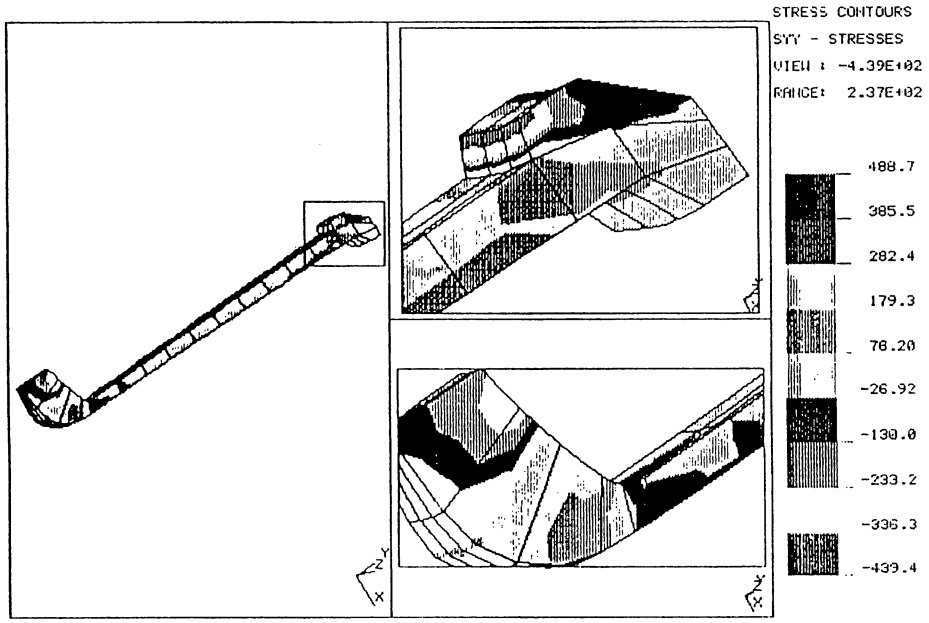

Fig.4 : Structural analysis of petal using NISA

The interface between collet and piston is provided with hard chrome plating. It is done on the piston to avoid indentation on the surface due to the contact with collet petals.
The information on the functional status is mission critical for issuing command to ignite the core booster. Interface for sensors and assembly procedure is planned during the design phase itself.

7. Development testing

Detailed development and qualification plan was made to realise the system with high reliability. A proto model was first realised and the concept was proved by pressurising the mechanism and achieving the release of shaft from collet grip.

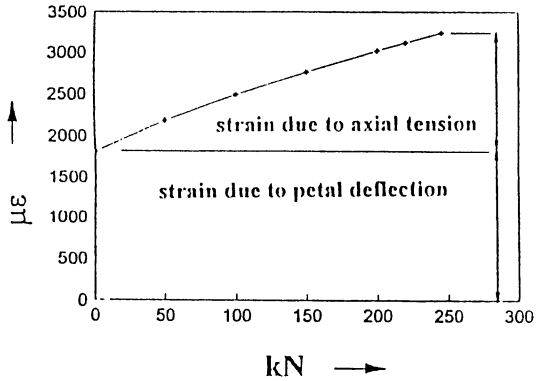

Fig.5 : Mechanism axial proof load test

The mechanisms were qualified for the load transmitted through the core base shroud during its structural load testing. Later one typical hardware was load tested for the proof load (Fig 5). The mechanism's hydraulic seals were tested by subjecting it to proof pressure of 30 MPa.

8. Conclusion

A unique compact release mechanism was designed for the launcher hold and release system. The mechanism is released by a multiple redundant hydraulic system.
The realisation of the system is in an advanced stage. Further qualification tests are planned with the actual hydraulic system to demonstrate the redundancy, release time and synchronisation. Qualification of system under the environment created by the thrusting strapons is planned along with the strapon engine test.

References

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